FLOOD INSURANCE STUDY

REVISED
PRELIMINARY

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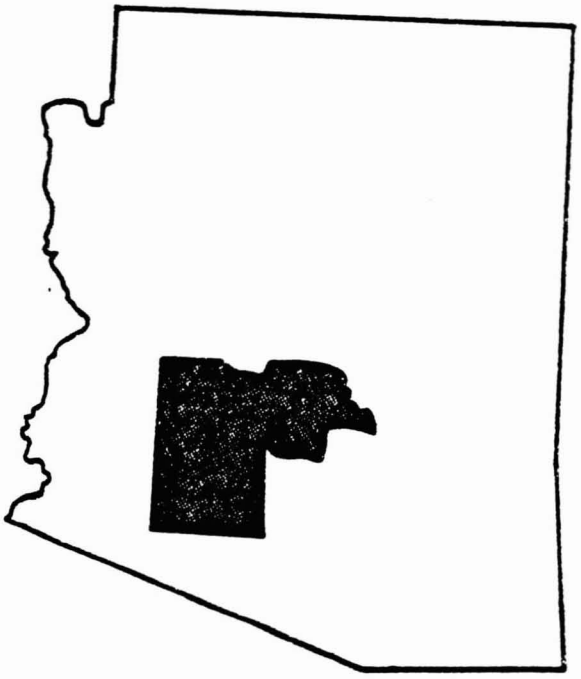

CITY OF PHOENIX, ARIZONA
MARICOPA COUNTY

FEMA

Federal Emergency Management Agency

COMMUNITY NUMBER - 040051

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index

Flood Insurance Rate Map

FLOOD INSURANCE STUDY
CITY OF PHOENIX, ARIZONA

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Flood Insurance Study is to investigate the existence and severity of flood hazards in the City of Phoenix, Maricopa County, Arizona, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This report is an update of the Flood Insurance Study published in June 1979 and reflects revisions that were necessary as a result of recent flood control projects, additional detailed studies and corporate boundary changes. This information will allow the City of Phoenix to continue participation in the regular phase of the National Flood Insurance Program with the most currently available data. Local and regional planners will use this study in their efforts to promote sound flood plain management.

1.2 Coordination

This Flood Insurance Study was coordinated with the City Engineer, Phoenix, Arizona, and the Federal Emergency Management Agency (FEMA). Southwest Computing Service, a local engineering firm, was contacted to obtain topographic data for the Salt River between 7th Street and 51st Avenue. Coordination between this study and the Maricopa County Flood Insurance Study was achieved at a meeting held on October 13, 1976, in Phoenix. This meeting was attended by representatives of Dames and Moore (D&M), Dewberry & Davis (D&D), the Harris Toups Corporation, the Maricopa County Flood Control District and the FEMA. D&M reviewed and revised the Flood Insurance Study for the unincorporated areas of Maricopa County and the Harris Toups Corporation has been contracted to study other areas in Maricopa County.

On March 3, 1977, a meeting was held between D&D, D&M, and the FEMA to further coordinate Flood Insurance Studies for the unincorporated areas of Maricopa County, the Cities of Phoenix, Mesa and Scottsdale, and the Town of Wickenburg, Arizona prior to final community coordination meetings for those communities.

A final Consultation and Coordination Officer's (CCO) meeting was held on November 16, 1977. This meeting was attended by representatives from the FEMA, D&D, the Harris Toups Corporation, the Maricopa County Flood Control District, the City of Phoenix and residents of Phoenix.

On September 4, 1979, a meeting was held to coordinate a restudy of Cave Creek and East Fork Cave Creek. A restudy of Cave Creek was required to determine the effect of the newly constructed Cave Buttes Dam on the 100-year flood plain. Similarly, East Fork Cave Creek was restudied to determine the effect of the Central Arizona Project (CAP), which significantly reduces the drainage area contributing to the flood hazard. The Central Arizona Project (CAP), an authorized project under the jurisdiction of the U.S. Bureau of Recalmation, would provide Colorado River water to the southcentral part of Arizona. The Granite Reef Aqueduct, the proposed CAP facility in the Phoenix project area, would be protected by an upstream dike several feet high with cross drainage structures (culverts and overchutes) designed to pass a 50-year flood. Those represented at that meeting were the City of Phoenix, the Maricopa County Flood Control District(MCFCD), Cella, Barr, Evans and Associates (CBEA as the study contractors), and the FEMA.

Throughout the course of the study, the study contractors were in communication with representatives of the FEMA and the City of Phoenix to ensure adherence to study procedures. On October 1, 1980, an intermediate meeting was held, attended by representatives of the City of Phoenix, the MCFCD, CBEA, the Arizona Department of Water Resources and the FEMA.

1.3 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968, and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were conducted by the Los Angeles District of the U. S. Army Corps of Engineers for the Federal Emergency Management Agency, under Inter-Agency Agreement No. IAA-H-15-72, Project Order No. 18 and Inter-Agency Agreement No. IAA-H-15-73, Project Order No. 3. This work was completed in September 1973.

The hydrologic and hydraulic analyses for the restudy of Cave Creek and East Fork Cave Creek were conducted by Cella, Barr, Evans and Associates for the Federal Emergency Management Agency, under contract no. H-4607. The work was completed in October 1980.

The 100-year profiles for Tenth Street Wash were revised by the City of Phoenix in April and July 1975. The 10-, and 500-year flood profiles, as well as a floodway for Tenth Street Wash were revised by Dewberry & Davis in November 1976. Curvilinear flood boundaries were done by Dewberry & Davis; these boundaries were taken from the rectalinear maps in the 1973 Flood Insurance Study. Flood boundaries in areas recently annexed by the City of Phoenix, which include flooding from the Agua Fria River and the New River, were taken from the Flood Insurance Study for the unincorporated areas of Maricopa County, revised in 1976 by Dames and Moore. Flood boundaries

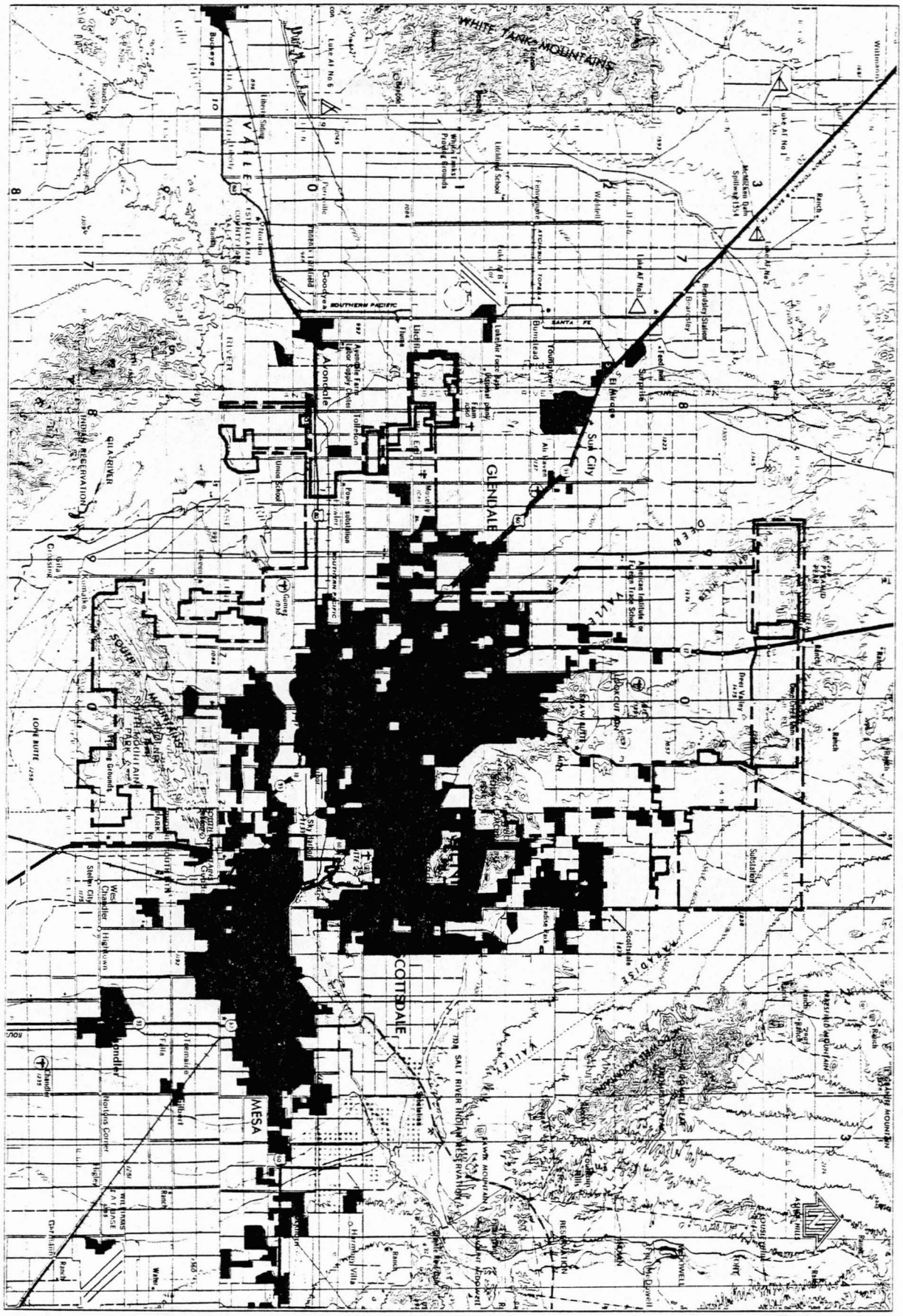


FIGURE 1

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

CITY OF PHOENIX, AZ
(MARICOPA CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

above Thunderbird Road on Moon Valley Wash were revised in November 1976 by the City of Phoenix. Flood profiles and the floodway for the Salt River were revised by the Harris Toups Corporation in October 1977.

Flooding associated with the Arizona, Grand and Western Canals was studied by the Harris Toups Corporation for the revision of February 1980. Flooding adjacent to Black Canyon Highway was studied by Dewberry & Davis between Skunk Creek and Scatter Wash.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Phoenix, Maricopa County, Arizona. The area of study is shown on the Vicinity Map (Figure 1).

Cave Creek, which flows from north to south through Phoenix, and the Salt River, which flows from east to west through the southern portion of Phoenix, are the major watercourses affecting the city. Indian Bend Wash has its source in the northwestern corner of Phoenix and, within three miles, flows into Paradise Valley to the east. Small reaches of the Agua Fria River and the New River flow from north to south through the western portion of Phoenix. In addition to these major channels, the following tributaries and mountain washes flow through the City of Phoenix: Moon Valley Wash, East Fork Cave Creek, West Branch East Fork Cave Creek, Cave Creek Tributary at Deer Valley Road, Scatter Wash, East Branch Scatter Wash, Tenth Street Wash, Northern Avenue Wash, Dreamy Draw Wash, Dreamy Draw Wash East, Myrtle Avenue Wash, Flynn Lane Wash, Echo Canyon Wash, and Skunk Creek. In addition, a system of major irrigation canals, including the Arizona, Grand, Roosevelt, Western, and Highline Canals, crosses the city from east to west.

Flooding on all of the aforementioned watercourses, excluding Indian Bend Wash and Northern Avenue Wash, was studied in detail. Flooding caused by the overflow and breakage of canals and ponding behind their elevated banks was studied by approximate methods because of the difficulty of analysis. Indian Bend Wash was studied by detailed methods in 1973. The hydrology in the Indian Bend Wash drainage area has changed significantly due to the completion of the central Arizona aqueduct and flood protection dike. The flood boundaries determined in 1973 have, therefore, been considered to be approximate in this study. The upper reaches of Cave Creek Tributary at Deer Valley Road, and portions of West Branch East Fork Cave Creek were also studied by approximate methods.

In the restudy, Cave Creek was studied by approximate methods from the Salt River, upstream approximately 3.2 miles to just below Durango Street. From that point, a detailed study was performed on Cave Creek up to the Cave Buttes Dam.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development or proposed construction for the next five years, through October 1985. Approximate methods of analysis were used to study those areas having low development potential and/or minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by the FEMA.

2.2 Community Description

The City of Phoenix, located in south-central Arizona in the eastern portion of Maricopa County, is the capital and largest city in the state. In 1974 the estimated population of the city was 780,000. This represents a 34 percent increase over the 1970 population of 582,500 (Reference 1). Metropolitan Phoenix, which includes the satellite communities of Scottsdale, Tempe, Mesa, Paradise Valley, Sun City, Carefree, Buckeye, Chandler and Glendale, plus the rest of the county, contained and estimated 1,173,000 residents in 1974. A steady growth rate is anticipated with a projected 1980 metropolitan area population of 1,600,000.

Incorporated on February 11, 1881, Phoenix is governed by a major-council form of government with a city manager as administrative office. The incorporated area of Phoenix has increased from 17.1 square miles in 1950 to 276.4 square miles in 1977.

Large portions of the flood plains within the city contain residential, commercial, and industrial development. Little streamflow occurs, except during and immediately following heavy precipitation, because climatic and drainage characteristics are not conducive to continuous runoff. None of the watercourses in the Phoenix study area flow perennially. Even the major rivers which flowed year round in their pristine states have been dried up by dams and diversions. Stream channels are distinct and well defined in the mountain ranges but upon reaching the valley transition they become braided and poorly defined, carrying most large flood discharges in their wide, flat flood plains. Urban areas are generally developed in a manner that tends to impede this type of flow. Streets provide the best avenue for runoff; interior streets have been laid out to facilitate local drainage, but their capacity to contain excess floodwater is limited. An underground storm drainage system exists in much of the city; however, its capacity is limited to runoff from storms having a recurrence interval of 1- or 2-years.

There is a system of major irrigation canals crossing the city from east to west nearly parallel to ground contours, which includes the Arizona, Grand, Roosevelt Irrigation Ditch, Western, and Highline Canals. The Arizona and Grand Canals were generally built high relative to the ground so they could irrigate adjacent fields by gravity. Because the canals are drained during severe storm conditions, they have been useful in the disposal of runoff. In many places, residential and other development has been carried up to the canal right-of-ways.

Most of the city lies at elevations between 1,000 and 1,500 feet. Scattered mountainous areas within the city rise to elevations of about 2,600 feet. Mountain areas are characterized by thin soils or exposed rock, sparse vegetation, and a terrain with many narrow canyons. Where streams leave the mountain canyons and enter the valley floor, they encounter deep and porous soils on mild slopes.

The climate of the Phoenix area is typically desert in character with short, mild winters and long, hot summers. Wide diurnal temperature variations are characteristic. Temperatures generally range between 35 degrees Fahrenheit (°F) and 105 °F degrees Fahrenheit, with an annual average of 71°F degrees. The prevailing winds are from the east and are usually light, although severe windstorms occur at rare intervals. The annual precipitation for the study area averages about 7.4 inches; however, this figure increases to about 24 inches in the headwater areas of the streams.

There are two separate rainfall seasons. The first occurs during the winter months from November to March when the area is subject to storms from the Pacific Ocean. While this is classified as a rainfall season, there can be periods of a month or more, in this or any other season, when practically no precipitation falls. Snowfall occurs very rarely in the study area, while light snows occasionally fall in the higher mountains surrounding the city. The second rainfall season occurs during July and August when Arizona is subject to widespread thunderstorm activity. These thunderstorms are extremely variable in intensity and location. The spring and fall months are generally dry, although precipitation in substantial amounts has fallen on occasion during every month of the year.

In general, the vegetation is very sparse. Cacti grow throughout the area. Several other desert shrubs such as Juniper, Paloverde, Mesquite, Ironwood, and Scrub Oak grow on the fairly level areas at the lower elevations. The vegetation tends to be thicker along stream courses. Perennial grasses form a negligible part of the vegetation, but good covers of annual grasses occur after the winter

rains. This natural vegetation has largely been replaced by residetial, commercial, and industrial development in the foothill and valley areas.

2.3 Principal Flood Problems

The most severe floods in the City of Phoenix generally occur during the summer as a result of local thunderstorms. The inadequate capacity of the stream channels and the rapid urbanization of the area, with resultant encroachment on the flood plain, has aggravated the flooding problem. Several irrigation canals, including the Arizona and Grand Canals, flow through the City of Phoenix. Large flood flows either break these canals directly or cause ponding behind the canals with subsequent breaks in the canals.

Severe local storms and floods have occurred in Phoenix in 1921, 1935, 1936, 1939, 1943, 1951, 1955, 1956, 1957, 1963, 1964, 1965, 1966, 1967, 1969, 1970, and 1972. During the August 1921 storm the runoff from 4 inches of rainfall on the Cave Creek watershed was estimated at 20,000 to 25,000 cubic feet per second (cfs). The June 1972 flood, which was caused by 5.25 inches of rainfall during an estimated 2-hour period, is estimated to have had a frequency of occurrence of 70 years. Photographs of flooding during 1965 and 1966 are shown in Figures 2 through 5.

2.4 Flood Protection Measures

Several flood control structures have been built during the last few years and many more are in the planning and design stages. Major flood control structures include the Paradise Valley detention dikes, which are a feature of the Central Arizona Project (CAP). These dikes, which should retain flows in excess of those caused by the 100-year storm, provide flood protection for the northeastern parts of Phoenix. The FEMA specifies that all levees must have a minimum of three foot freeboard against 100-year flooding to be considered a safe flood protection structure. The Paradise Valley detention dikes have a 14 foot freeboard against the 100-year flood. The remaining flood control structures do to meet the FEMA requirement.

The U.S. Army Corps of Engineers (COE) is sponsoring a project known as the New River and Phoenix City Streams, Phase B. Three features of this project which effect Phoenix are Dreamy Draw Dam, which has already been completed; Cave Buttes Dam, which was completed in March 1980 and was designed to protect against the standard project flood (approximately the 500-year storm in Arizona); and the Arizona Canal Diversion Channel, which is scheduled to begin construction no earlier than 1985 and is also designed for a standard project flood.

The City of Phoenix has completed five flood detention basins capable of providing protection against the 100-year flood near 7th and Peoria Avenues, near 7th Street and Thunderbird Road, and Cave Creek Road's approximate intersection with 16th Street.

Figure 2 - Looking downstream on the Salt River during the 1965 flooding. Sky Harbor International Airport runways are in the center.

Figure 3 - Salt River flooding in 1965. The 40th Street bridge railing is visible at lower right. Flow is from right to left.

Figure 4 - Flooding at the Central Avenue bridge over the Salt River on January 7, 1966. Note how one pier has fallen four feet. Flow is from left to right.

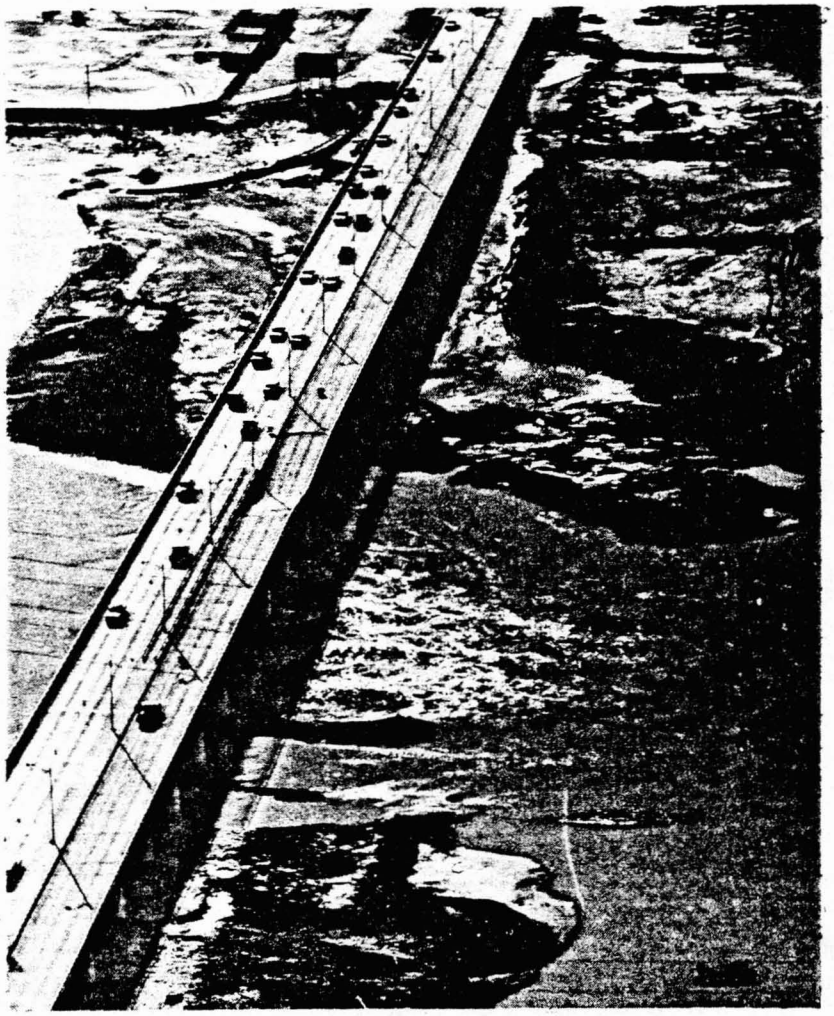


Figure 5 - Flooding at the Central Avenue bridge over the Salt River on January 3, 1966. Flow is from left to right.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Floods having recurrence intervals of 10, 50, 100, and 500 years have been selected as having special significance for flood plain management and for flood insurance premium rates. The analyses reported here reflect current conditions in the watersheds of the flooding sources.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail in the community.

Discharge-frequency relationships for streams in the study area were developed using a flood frequency regression analysis of stream-flow records for 43 gages in south-central Arizona in conjunction with a determination of the flood in excess of the 350-year flood. The drainage areas at the gaging stations in the analysis ranged from 0.13 to 417 square miles; lengths of record ranged from 4 to 42 years. Graphical frequency curves were drawn for each of these gages using the procedures outlined in Beard's Statistical Methods in Hydrology (Reference 2). Zero flows were ranked along with the positive flows; hence, the entire period of record was utilized for each stream gage. The 100-, 50-, 25-, 10-, 5-, and 2-year peak discharges were then used as the dependent variables in the regression analysis.

The regression analysis was performed using the Hydrologic Engineering Center Program 704-G9-L2020 Multiple Regression Package (Reference 3). Regression equations were derived for streams with drainage areas of less than 30 square miles in size and for drainage areas between 30 and 417 square miles in size. Independent variables found to be the most closely related to peak-flood discharges in the Phoenix area were drainage area, basin slope, and 5-year and 24-hour rainfall.

The standard project flood was computed using the local standard project storm and precipitation-runoff relationships. The standard project flood is a hypothetical flood which would be the result of a combination of the most severe meteorological and hydrologic conditions that are considered reasonably characteristic of the geographical region involved. The August 19, 1954 thunderstorm that was centered generally in the Queen Creek drainage area was selected

as the standard project flood for the central portion of Arizona. This storm was transposed to the Phoenix area on the basis of 10-year, 6-hour precipitation. data from observed flood events in the Phoenix area provided the basis for the rainfall runoff relationships used in this study. Runoff was computed using synthetic unit hydrographs.

The discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year floods were computed at various points along each stream covered by the analysis and plotted on log-probability paper. At points where the standard project flood had less than a 500-year recurrence interval, the curve was extrapolated to obtain a 500-year peak discharge.

The construction of a detention basin in the headwaters of the Tenth Street Wash necessitated a further evaluation of peak discharges along this flooding source. Discharges were first computed without the detention basin in place using the modified rational method (Reference 4) and adjusted to agree with the values determined in the regression analysis. Discharges were then determined assuming a metered flow from the detention basin.

The 100-year peak discharges for the Moon Valley Wash were determined at selected locations by use of the Soil Conservation Service's TR-20 Hydrology Program (Reference 5). This method used drainage basin characteristics to develop 100-year conditions which were substantially lower than those originally computed. These lower flows have been used for this study.

Hydrology for the Cave Creek restudy was supplied by the COE and reviewed by CBEA. The standard project flood peak discharge was determined using a stream system approach (i.e. hydrologic routing using a combination of sub-basin hydrographs). The COE flood hydrograph package was used to develop sub-basin hydrographs. This rainfall runoff model was calibrated against many known flood events. The 100-, 50-, and 10-year peak discharges were computed as a percentage of the standard project flood.

East Fork Cave Creek is hydrologically similar to Cave Creek. Therefore, the drainage area-peak discharge relationships developed for Cave Creek were applied to East Fork Cave Creek.

For both Cave Creek and East Fork Cave Creek, the 500-year peak discharge was obtained through extrapolation of the discharge frequency curves.

For larger magnitude floods on Cave Creek, discharges tend to decrease proceeding downstream of the Arizona Canal. This is also

true for all floods on the Salt River. The primary reason for this is the wide shallow flood plain available for overbank storage.

Peak discharges for the 10-, 50-, 100-, and 500-year floods of the streams studied in detail are shown in Table 1, "Summary of Discharges." No data were available for East Branch Scatter Wash and Skunk Creek.

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
CAVE CREEK					
Above Deer Valley Road	4.51	1,300	3,500	5,000	10,000
Below Deer Valley Road	5.00	1,400	3,800	5,400	11,000
Above confluence of East Fork Cave Creek	8.10	1,600	4,200	5,800	11,500
Below confluence of East Fork Cave Creek	22.50	3,100	8,700	12,000	25,000
Below confluence of Moon Valley Wash	29.25	3,200	9,000	13,000	27,000
At crossing of Arizona Canal	30.35	3,200	9,000	13,000	27,000
At crossing of Grand Canal	50.40	3,100	8,600	12,400	26,000
At confluence with the Salt River	96.60	2,800	7,700	10,900	22,000
EAST FORK CAVE CREEK					
At Beardsley Road	0.96	600	1,500	2,100	4,300
At Utopia Road	1.80	800	2,100	3,000	5,800
At Cave Creek Road	2.95	1,000	2,800	3,900	7,900
At Bell Road	3.36	1,100	2,900	4,200	8,200
Below 7th Street	12.40	2,200	5,900	8,400	17,000
Below 7th Avenue, extended	13.80	2,300	6,300	8,900	18,000
At confluence with Cave Creek	14.40	2,300	6,400	9,000	19,000
CAVE CREEK TRIBUTARY AT DEER VALLEY ROAD					
At mouth	0.80	600	1,400	1,750	2,600
WEST BRANCH EAST FORK CAVE CREEK					
At mouth	0.67	500	800	1,000	2,300

TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
ECHO CANYON WASH					
200 feet East of 40th Street	4.30	1,900	4,200	5,900	14,000
At confluence with Arizona Canal	5.13	2,000	4,600	6,600	18,000
MOON VALLEY WASH					
At Confluence with Cave Creek	6.52	2,000	5,000	7,300	21,000
SCATTER WASH					
At mouth	1.25	1,000	2,400	3,000	3,700
MYRTLE AVENUE WASH					
At mouth	0.87	600	1,000	1,300	2,800
FLYNN LANE WASH					
At Flynn Lane and Lincoln Dr.	0.63	400	800	1,100	2,300
At Ocotillo Road	0.98	700	1,300	1,700	3,300
TENTH STREET WASH					
At Cheryl Drive	0.81	385	*	1,440	3,650
At Hatcher Road	1.59	910	*	3,400	8,600
At Alice Avenue	2.25	1,170	*	4,390	11,110
At Griswold Road	2.69	1,265	*	4,740	12,000
DREAMY DRAW WASH EAST					
At mouth	0.38	300	750	1,000	1,700
SALT RIVER					
At Mill Avenue bridge	13,260	47,000	130,000	178,500	368,000
At confluence with the Gila River	13,700	37,000	104,000	145,000	290,000

*Data not available

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Cross section data for all streams except Cave Creek and East Fork Cave Creek were obtained from topographic maps at a scale of 1:1,200 with a contour interval of two feet (Reference 6). Cross

sections were located at close intervals above and below bridges and culverts in order to compute the significant backwter effects of these structures. Ford crossings are numerous in this area and are depicted in this Flood Insurance Study accordingly. Only two bridge structures on the Salt River were modeled because these were considered to be the bridges which could adequately pass the higher discharges. Although the remaining bridges were not modeled, their approach geometry generated fairly large head losses. Locations of selected cross-sections used in the hydraulic analyses are shown on the Flood Profiles Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 3). Cross-sections used on the Agua Fira and New Rivers were taken outside the corporate limits and are thus not shown.

Cross-section data for the Cave Creek and East Fork Cave Creek restudy were obtained from two separate sources. Mapping for all of East Fork Cave Creek and that portion of Cave Creek below the Arizona Canal was obtained from aerial photographs flown in March 1980 at a scale of 1:12,000 (Reference 7). The topographic mapping was compiled at a scale of 1:3,600 with a four foot contour interval. Mapping for above the Arizona Canal was obtained by the COE. The area was flown in March 1978 at a scale of 1:6,000 (Reference 8). The topographic mapping was compiled at a scale of 1:2,400 with a two foot contour interval.

Roughness coefficients (Manning's "n" values) for all detailed studied streams were established on the basis of field investigations. Values of the roughness coefficients for all streams ranged from 0.015 to 0.050 for the channel and from 0.015 to 0.07 for the overbank areas.

In the Cave Creek and East Fork Cave Creek restudy, roughness coefficients were estimated from field observations and engineering experience. A technique described in the U. S. Geological Survey, Research Journal, was utilized for estimating roughness coefficients in urbanized areas (Reference 9).

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Water-surface elevations for all streams of floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 10). Starting water-surface elevations for all streams except the Salt River were determined by the slope/area method. For the Salt River, starting elevations were taken at the confluence with the Gila River (Reference 11). All elevations used in this study are referenced to National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929. Locations of the elevation reference marks used in the study are shown on the maps.

The 100-year flood elevation for Indian Bend Wash has also been determined through use of the HEC-2 computer program; however, this flooding source has been designated as an area of approximate study due to the effects of the central Arizona aqueduct and dikes on Indian Bend Wash.

For the Arizona, Grand and Western Canals, the hydraulic analysis was based on available mapping, field investigations, field surveyed cross sections and appropriate methodologies. Cross sections were taken perpendicular to the flow on the up-slope side at selected locations. Depths were then averaged over the areas of inundation to determine the appropriate zone.

The hydraulic analyses on the streams for this study are based only on the effects of unobstructed flow. The flood elevations as shown on the profiles are thus considered valid only if hydraulic structures in general remain unobstructed.

Overflow from Skunk Creek along Black Canyon Highway between Skunk Creek and Scatter Wash was approximated by normal depth computations.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage state and local governments to adopt sound flood plain management programs. Each Flood Insurance Study, therefore, includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FEMA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:1,200 with a contour interval of two feet (Reference 6). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year boundary has been shown.

For Indian Bend Wash, which has been designated as an area of approximate study, the same procedure was used as outlined for streams studied in detail; however, only the 100-year flood boundary has been

delineated. Special Flood Hazard Area boundaries for the canals were determined by projecting the top of canal banks to the upslope natural ground.

Boundaries of flooding resulting from inadequate drainage in Moon Valley above Thunderbird Road were drawn based on experience and judgement using the topographic maps mentioned previously. Boundaries in areas recently annexed by the city were obtained from the Flood Insurance Study for the unincorporated areas of Maricopa County, Arizona, as revised by D & M (Reference 12). These boundaries include areas on the Agua Fria River and the New River near their confluence and sheet flooding due to inadequate drainage in certain western portions of Phoenix. Due to the flatness of the land, the 100-year flood will produce shallow flooding less than one foot in depth over most of the area. For this reason, most of Phoenix has been designated as a moderate flood hazard area.

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 3). Small areas within the flood boundaries may lie above the flood elevations, and therefore may not be subject to flooding. Owing to limitations of the map scale, or lack of detailed topographic information, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases flood heights, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of the FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The Flood Plain Ordinance for the City of Phoenix restricts the velocity at floodway encroachments to be less than or equal to 5.0 feet per second. FEMA criteria were used to delineate the floodways in this study; thus, floodways delineated under Flood Plain Ordinance for Phoenix may be more restrictive.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

For Cave Creek, a major breakout will occur downstream of 7th Street, just west of an existing sand and gravel operation, due to a lack of channel capacity. The flood plain below the breakout was delineated using the decreased discharge. The full 100-year discharge was used to determine the floodway downstream of the breakout and it was found that the discharge could not be confined to the 100-year flood plain without incurring a surcharge of more than one foot. Therefore a floodway was not delineated between the confluence of East Fork Cave Creek and upstream of the breakout.

As shown on the Flood Boundary and Floodway Map (Exhibit 3), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. For East Branch Scatter Wash there is no defined channel, and the flow through it was mainly from the breakout of Skunk Creek. Since the flow situation will be changed after the completion of levees on Skunk Creek upstream of Black Canyon Highway in 1980, no floodway was delineated for this stream. Cross sections on the Agua Fria River and the New River were not shown on the Flood Boundary and Floodway Map because they were located outside the corporate limits. Portions of the floodway widths for Scatter Wash, the Salt River and Skunk Creek extend beyond the corporte limits. In cases where the boundaries of the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 6.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source studied in detail affecting the City of Phoenix.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Cave Creek								
A	15.28	3,415	4,011	3.2	1,235.6	1,235.6	1,236.6	1.0
B	15.53	1,500	2,782	4.7	1,240.7	1,240.7	1,241.3	0.6
C	15.65	1,420	3,646	3.6	1,242.6	1,242.6	1,243.3	0.7
D	15.85	1,375	2,866	4.5	1,247.7	1,247.7	1,248.2	0.5
E	15.94	1,385	5,207	2.5	1,251.0	1,251.0	1,251.9	0.9
F	16.01	812	2,594	5.0	1,251.4	1,251.4	1,252.1	0.7
G	16.12	420	1,835	7.1	1,253.8	1,253.8	1,254.5	0.7
H	16.24	430	1,544	8.4	1,256.7	1,256.7	1,256.8	0.1
I	16.35	495	1,569	8.3	1,259.9	1,259.9	1,260.1	0.2
J	16.46	235	1,487	8.7	1,261.6	1,261.6	1,262.6	1.0
K	16.59	205	1,556	8.4	1,264.2	1,264.2	1,264.6	0.4
L	16.71	324	1,764	7.4	1,266.0	1,266.0	1,266.4	0.4
M	16.84	167	977	13.3	1,268.2	1,268.2	1,268.4	0.2
N	16.92	172	1,306	10.0	1,271.7	1,271.7	1,272.1	0.4
O	17.00	124	866	15.0	1,273.3	1,273.3	1,273.6	0.3
P	17.06	290	2,620	5.0	1,277.8	1,277.8	1,278.3	0.5
Q	17.26	196	1,307	9.9	1,278.0	1,278.0	1,278.8	0.8
R	17.37	225	2,062	6.3	1,280.2	1,280.2	1,281.0	0.8
S	17.49	210	1,090	11.9	1,281.1	1,281.1	1,281.6	0.5

[1] Miles above confluence with Salt River

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOODWAY DATA

CAVE CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE [1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Cave Creek (continued)								
T	17.57	357	2,067	5.8	1,284.4	1,284.4	1,284.9	0.5
U	17.67	280	2,243	5.4	1,285.0	1,285.0	1,285.8	0.8
V	17.77	195	946	12.7	1,286.2	1,286.2	1,286.5	0.3
W	17.93	200	1,316	9.1	1,293.9	1,293.9	1,294.3	0.4
X	18.05	86	1,201	10.0	1,297.6	1,297.6	1,298.3	0.7
Y	18.39	199	1,617	7.4	1,299.7	1,299.7	1,300.7	1.0
Z	18.53	173	1,294	9.3	1,301.0	1,301.0	1,301.8	0.8
AA	18.68	142	901	13.3	1,303.4	1,303.4	1,303.8	0.4
AB	18.75	161	1,275	9.4	1,306.2	1,306.2	1,306.7	0.5
AC	18.89	163	1,171	10.2	1,308.0	1,308.0	1,308.5	0.5
AD	18.96	197	1,554	7.7	1,309.6	1,309.6	1,310.1	0.5
AE	19.05	152	874	13.7	1,309.8	1,309.8	1,310.2	0.4
AF	19.16	129	1,123	10.7	1,315.3	1,315.3	1,315.8	0.5
AG	19.24	145	1,169	10.3	1,316.6	1,316.6	1,317.2	0.6
AH	19.28	129	1,025	11.7	1,317.1	1,317.1	1,317.6	0.5
AI	19.30	108	1,118	10.7	1,322.8	1,322.8	1,323.4	0.6
AJ	19.33	173	1,544	7.8	1,324.0	1,324.0	1,324.7	0.7

[1] Miles above confluence with Salt River

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOODWAY DATA

CAVE CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE [1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Cave Creek (continued)								
AK	19.42	161	1,278	9.4	1,324.6	1,324.6	1,325.2	0.6
AL	19.56	115	827	14.5	1,326.4	1,326.4	1,326.7	0.3
AM	19.65	327[2]	1,336	4.3	1,331.7	1,331.7	1,332.2	0.5
AN	19.73	103	787	7.4	1,332.0	1,332.0	1,332.6	0.6
AO	19.83	87	676	8.6	1,332.8	1,332.8	1,333.7	0.9
AP	24.61	87	405	12.4	1,474.0	1,474.0	1,474.0	0.0
AQ	24.71	210	868	5.8	1,480.5	1,480.5	1,480.8	0.3
AR	24.86	280	1,116	4.5	1,483.4	1,483.4	1,484.1	0.7
AS	25.06	205	541	9.2	1,489.9	1,489.9	1,490.4	0.5
AT	25.12	225	1,077	4.6	1,492.2	1,492.2	1,493.2	1.0
AU	25.22	130	463	10.8	1,495.1	1,495.1	1,496.0	0.9
AV	25.29	185	810	6.2	1,499.7	1,499.7	1,500.7	1.0
AW	25.37	137	672	7.4	1,503.2	1,503.2	1,503.2	0.0
AX	25.42	86	472	10.6	1,504.1	1,504.1	1,504.5	0.4
AY	25.46	75	520	9.6	1,507.1	1,507.1	1,507.1	0.0
AZ	25.50	100	810	6.2	1,515.1	1,515.1	1,515.1	0.0
BA	25.57	150	965	4.1	1,515.4	1,515.4	1,515.8	0.4
BB	25.72	178	553	7.2	1,516.7	1,516.7	1,517.6	0.9

[1] Miles above confluence with Salt River

[2] Combined floodway for Cave Creek and East Fork Cave Creek

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

CAVE CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
East Fork Cave Creek								
A	0.08	377	1,276	7.1	1,332.8	1,332.8	1,332.8	0.0
B	0.12	260	760	11.8	1,332.8	1,332.8	1,332.8	0.0
C	0.17	255	1,498	6.0	1,335.4	1,335.4	1,335.4	0.0
D	0.24	166	1,402	6.4	1,335.8	1,335.8	1,335.8	0.0
E	0.35	213	1,552	5.8	1,338.6	1,338.6	1,339.1	0.5
F	0.47	270	1,657	5.4	1,339.4	1,339.4	1,340.1	0.7
G	0.54	169	726	12.4	1,342.5	1,342.5	1,342.5	0.0
H	0.89	180	1,181	7.5	1,350.4	1,350.4	1,351.1	0.7
I	1.01	230	1,603	5.6	1,352.0	1,352.0	1,353.0	1.0
J	1.19	170	1,306	6.8	1,355.0	1,355.0	1,355.4	0.4
K	1.27	220	1,044	8.0	1,356.0	1,356.0	1,356.6	0.6
L	1.39	460	1,684	5.0	1,359.0	1,359.0	1,359.6	0.6
M	1.49	400	1,343	6.3	1,361.0	1,361.0	1,361.6	0.6
N	1.85	449	1,617	5.2	1,372.8	1,372.8	1,373.7	0.9
O	2.07	670	1,857	4.0	1,377.6	1,377.6	1,378.3	0.7
P	2.30	772	2,090	3.6	1,384.4	1,384.4	1,385.4	1.0
Q	2.44	812	1,599	4.7	1,387.7	1,387.7	1,388.7	1.0
R	2.75	649	1,392	5.4	1,395.9	1,395.9	1,396.7	0.8

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

EAST FORK CAVE CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
East Fork Cave Creek (continued)								
S	3.07[1]	370	895	4.7	1,407.8	1,407.8	1,407.9	0.1
T	3.22[1]	570	969	4.0	1,412.1	1,412.1	1,412.7	0.6
U	3.42[1]	977	1,066	3.7	1,418.9	1,418.9	1,419.2	0.3
V	3.61[1]	1,190	1,226	3.2	1,426.1	1,426.1	1,426.4	0.3
W	3.78[1]	1,200	1,612	2.4	1,431.9	1,431.9	1,432.8	0.9
X	4.09[1]	430	829	4.7	1,441.4	1,441.4	1,441.8	0.4
Y	4.32[1]	410	829	4.7	1,449.4	1,449.4	1,449.9	0.5
Cave Creek Tributary at Deer Valley Road								
A	0.63[2]	380	*	*	1,496.2	1,496.2	1,496.2	0.0
B	0.86[2]	200	*	*	1,503.4	1,503.4	1,503.4	0.0
C	1.17[2]	360	*	*	1,515.7	1,515.7	1,515.7	0.0

[1]Miles above confluence with Cave Creek
[2]Miles above mouth
*Data not available

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

EAST FORK CAVE CREEK AND CAVE CREEK TRIBUTARY AT DEER VALLEY

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
West Branch East Fork Cave Creek								
A	0.53	160	163	6.2	1,364.4	1,364.4	1,364.6	0.2
B	0.73	320	414	2.4	1,370.3	1,370.3	1,370.3	0.0
Echo Canyon Wash								
A	0.51	150	1,432	4.1	1,271.7	1,271.7	1,272.7	1.0
B	0.71	180	1,466	4.0	1,278.0	1,278.0	1,278.8	0.8
C	1.04	210	1,501	3.9	1,293.1	1,293.1	1,293.5	0.4
D	1.19	180	1,169	5.0	1,298.0	1,298.0	1,298.3	0.3
Moon Valley Wash								
A	0.47	*	**	**	1,290.7	1,290.7	1,290.7	0.0
B	0.74	1,000	**	**	1,300.0	1,300.0	1,300.9	0.9
C	0.88	1,000	**	**	1,306.9	1,306.9	1,307.2	0.3

[1]Miles above mouth
*Floodway contained in channel
**Data Not Available

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOODWAY DATA

WEST BRANCH EAST FORK CAVE CREEK, ECHO CANYON WASH, AND MOON VALLEY WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Scatter Wash								
A	0.40	620	*	4.6	1,333.2	1,333.2	1,334.0	0.8
B	0.80	560	*	4.5	1,343.7	1,343.7	1,344.4	0.7
C	1.30	470	*	5.4	1,357.7	1,357.7	1,358.5	0.8
D	1.80	270	*	2.6	1,366.8	1,366.8	1,367.5	0.7
E	2.30	120	*	4.5	1,380.9	1,380.9	1,381.0	0.1
F	2.80	200	*	4.5	1,396.2	1,396.2	1,397.0	0.8
G	3.00	185	*	2.8	1,402.5	1,402.5	1,402.8	0.3
H	3.38	520	*	*	1,416.0	1,416.0	1,416.0	0.0
I	3.55	320	*	*	1,417.0	1,417.0	1,417.0	0.0
J	3.92	980	*	*	1,430.5	1,430.5	1,430.5	0.0
K	4.40	1,800	*	*	1,445.0	1,445.0	1,445.1	0.1
L	4.67	770[2]	*	*	1,455.7	1,455.7	1,455.7	0.0
M	5.04	780[2]	*	*	1,471.4	1,471.4	1,471.5	0.1
Myrtle Avenue Wash								
A	0.04	250[3]	*	*	1,242.0	1,242.0	1,242.9	0.9
B	0.22	250	*	*	1,260.2	1,260.2	1,260.8	0.6

[1]Miles above mouth
[2]Part of floodway located outside of corporate limits
[3]Combined floodway for Myrtle Avenue Wash and Dreamy Draw Wash East.
*Data not available

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

SCATTER WASH AND MYRTLE AVENUE WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Flynn Lane Wash								
A	0.05	350	*	*	1,244.3	1,244.3	1,244.7	0.4
B	0.21	250	*	*	1,259.8	1,259.8	1,259.9	0.1
C	0.34	200	*	*	1,272.5	1,272.5	1,273.0	0.5
D	0.53	400	*	*	1,290.1	1,290.1	1,291.1	1.0
Tenth Street Wash								
A	0.09	1,590	*	*	1,241.8	1,241.8	1,242.8	1.0
B	0.31	370	*	*	1,246.5	1,246.5	1,247.4	0.9
C	0.54	530	*	*	1,257.6	1,257.6	1,258.5	1.0
D	0.74	400	*	*	1,267.7	1,267.7	1,268.7	1.0
E	0.92	140	*	*	1,278.6	1,278.6	1,279.6	1.0
F	1.12	260	*	*	1,287.5	1,287.5	1,288.5	1.0
G	1.37	80	*	*	1,297.3	1,297.3	1,298.3	1.0
H	1.50	250	*	*	1,306.0	1,306.0	1,306.0	0.0
I	1.75	80	*	*	1,314.4	1,314.4	1,315.1	0.7
J	1.91	60	*	*	1,323.2	1,323.2	1,323.4	0.2
K	2.13	315	*	*	1,337.5	1,337.5	1,337.5	0.0
L	2.28	100	*	*	1,350.4	1,350.4	1,350.4	0.0

[1] Miles above mouth

*Data not available

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOODWAY DATA

FLYNN LANE WASH AND TENTH STREET WASH

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Dreamy Draw Wash East								
A	0.04[2]	250[4]	*	*	1,242.0	1,242.0	1,242.9	0.9
Salt River[1]								
A-C								
D	2.90[3]	3302/1470[5]	26,536	5.6	965.5	965.5	966.4	0.9
E	3.11[3]	3489/1350[5]	27,041	5.6	966.6	966.6	967.4	0.8
F	3.30[3]	3198/1460[5]	26,825	5.6	968.1	968.1	968.7	0.6
G	3.56[3]	2911/1740[5]	23,580	6.4	970.0	970.0	970.4	0.4
H	3.76[3]	2856/1990[5]	26,870	5.6	971.9	971.9	972.6	0.7
I-R[1]								
S	8.80[3]	3121/700[5]	20,499	7.9	1,015.7	1,015.7	1,016.2	0.5
T	9.00[3]	3875/1280[5]	21,832	7.5	1,016.7	1,016.7	1,017.3	0.6
U	9.20[3]	3917/1690[5]	24,665	6.6	1,019.8	1,019.8	1,020.1	0.3
V	9.60[3]	3780/2220[5]	29,325	5.6	1,023.1	1,023.1	1,023.6	0.5
W	10.18[3]	3260/2280[5]	19,409	8.5	1,027.9	1,027.9	1,028.1	0.2
X	10.57[3]	2,660	23,445	7.0	1,032.3	1,032.3	1,032.7	0.4
Y	10.96[3]	3,150	19,878	8.3	1,035.3	1,035.3	1,035.8	0.5
Z	11.22[3]	2,700	18,912	8.8	1,036.4	1,036.4	1,037.4	1.0
AA	11.39[3]	2,725	21,649	7.7	1,039.8	1,039.8	1,040.2	0.4

[1] Cross sections located outside corporate limits
[2] Miles above mouth
[3] Miles from 115th Avenue
[4] Combined floodway for Dreamy Draw Wash East and Myrtle Avenue Wash
[5] Width/width within corporate limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

DREAMY DRAW WASH EAST AND SALT RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Salt River (continued)								
AA	11.39	2,725	21,649	7.7	1,039.8	1,039.8	1,040.2	0.4
AB	11.58	2,660	38,378	4.4	1,041.2	1,041.2	1,041.7	0.5
AC	11.98	2,830	23,367	7.1	1,041.9	1,041.9	1,042.4	0.5
AD	12.20	2,750	17,390	9.7	1,044.0	1,044.0	1,044.4	0.4
AE	12.40	2,625	21,596	7.8	1,047.3	1,047.3	1,047.3	0.0
AF	12.85	2,091	16,694	10.1	1,049.9	1,049.9	1,049.9	0.0
AG	13.06	2,072	10,865	15.6	1,052.9	1,052.9	1,052.9	0.0
AH	13.20	1,830	26,980	6.3	1,056.9	1,056.9	1,057.4	0.5
AI	13.93	1,830	21,919	7.7	1,508.7	1,058.7	1,059.4	0.7
AJ	14.51	1,483	28,480	6.0	1,064.3	1,064.3	1,064.6	0.3
AK	14.95	968	19,473	8.8	1,065.1	1,065.1	1,065.4	0.3
AL	15.22	930	10,094	17.0	1,068.4	1,068.4	1,069.3	0.9
AM	15.50	1,302	21,802	7.9	1,081.7	1,081.7	1,081.7	0.0
AN	15.85	1,795	37,449	4.6	1,083.0	1,083.0	1,083.1	0.1
AO	16.37	1,700	14,433	12.0	1,084.5	1,084.5	1,084.7	0.2
AP	16.65	2,047	23,140	7.5	1,091.2	1,091.2	1,091.6	0.4
AQ	16.77	2,051	19,930	8.7	1,091.8	1,091.8	1,092.2	0.4
AR	17.26	2,879	23,749	7.3	1,096.4	1,096.4	1,097.1	0.7

[1] Miles from 115th Avenue

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

SALT RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Salt River (continued)								
AS	17.74[1]	3,394	26,168	6.6	1,103.6	1,103.6	1,104.1	0.5
AT	18.14[1]	2,742	25,852	6.8	1,108.4	1,108.4	1,108.5	0.1
AU	18.44[1]	2,993	23,492	7.4	1,111.2	1,111.2	1,111.2	0.0
AV	19.07[1]	3,050	24,032	7.3	1,113.8	1,113.8	1,113.8	0.0
AW	19.68[1]	4,268	28,580	6.2	1,121.2	1,121.2	1,121.2	0.0
AX	19.96[1]	4,320	18,301	9.6	1,123.0	1,123.0	1,123.0	0.0
AY	20.25[1]	4,400	29,117	6.1	1,127.0	1,127.0	1,127.6	0.6
AZ	20.50[1]	4,750	25,228	7.0	1,128.5	1,128.5	1,129.3	0.8
BA	21.05[1]	3,755	22,554	7.9	1,134.6	1,134.6	1,135.5	0.9
BB	21.16[1]	3300/1200[3]	23,337	7.6	1,136.5	1,136.5	1,137.4	0.9
BC	21.35[1]	2888/1400[3]	20,933	8.5	1,138.5	1,138.5	1,139.5	1.0
BD	21.72[1]	3470/1160[3]	26,746	6.7	1,142.5	1,142.5	1,143.5	1.0
Skunk Creek								
A	5.90[2]	1,110	*	5.0	1,305.4	1,305.4	1,305.9	0.5
B	6.50[2]	1,755	*	5.1	1,319.5	1,319.5	1,319.8	0.3
C	6.84[2]	2,010[4]	*	4.8	1,328.9	1,328.9	1,329.6	0.7
D	7.00[2]	790	*	7.8	1,335.2	1,335.2	1,336.0	0.8

[1] Miles from 115th Avenue
[2] Miles above mouth
[3] Width/width within corporate limits
[4] Combined floodway for Skunk Creek and Scatter Wash
*Not computed

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOODWAY DATA

SALT RIVER AND SKUNK CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Skunk Creek (continued)								
E	7.50	920	*	5.3	1,347.6	1,347.6	1,348.4	0.8
F	8.00	870	*	6.0	1,359.9	1,359.9	1,360.8	0.9
G	8.80	1,220	*	5.3	1,383.5	1,383.5	1,384.1	0.6
H	9.10	1,550[2]	*	4.5	1,393.5	1,393.5	1,394.5	1.0
I	9.50	1,900[2]	*	4.2	1,403.8	1,403.8	1,404.6	0.8
J	10.00	865	*	2.8	1,420.5	1,420.5	1,419.6	0.9
K	10.50	620	*	5.4	1,437.9	1,437.9	1,437.1	0.8
L	11.00	1,990[2]	*	4.2	1,453.3	1,453.3	1,453.1	0.2

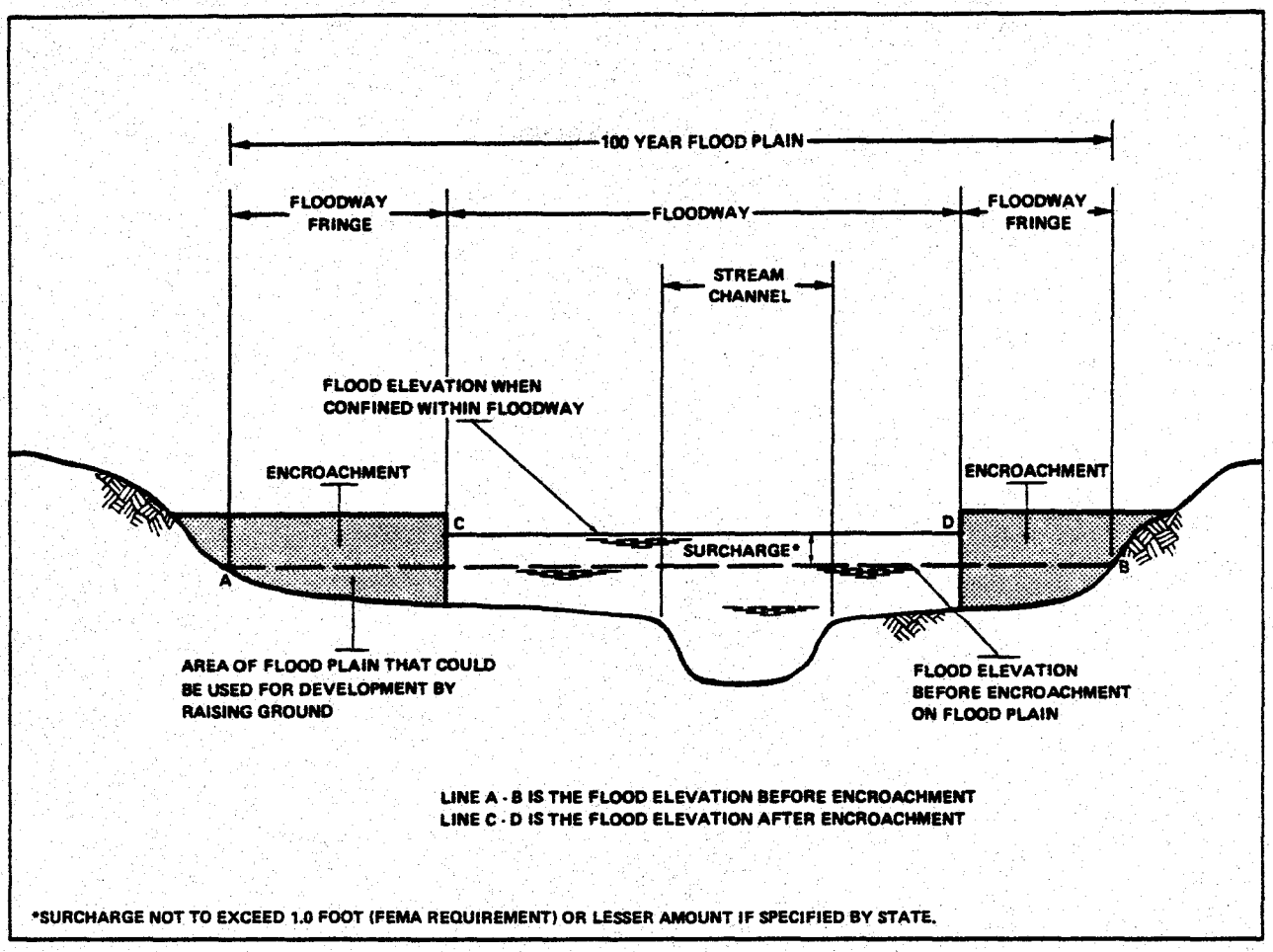
[1] Miles above mouth
[2] This width extends beyond corporate limits
* Not computed

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOODWAY DATA

SKUNK CREEK



FLOODWAY SCHEMATIC

The locations of the reaches determined for the flooding sources of the City of Phoenix are shown on the Flood Profiles (Exhibit 1) and are summarized in the Flood Insurance Zone Data Table (Table 3).

5.2 Flood Hazard Factors

The FHF is the FEMA device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area for the City of Phoenix was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zone A0:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, but no FHFs are determined.
Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no Flood Hazard Factors are determined.
Zones A1, A2, A3, A4, A5, A7, A8, A9, A10, A13, A17,	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones assigned according to FHFs.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas

Zone B: (continued)	subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of Minimal Flooding; including areas that are protected from 100- and 500-year floods by dike, levee, or other water control structure; not subdivided.

Table 3, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the City of Phoenix.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Phoenix is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FEMA.

6.0 OTHER STUDIES

The 1979 Flood Insurance Study for the City of Phoenix has been revised using data from several drainage studies done later to reflect changing conditions in a rapidly developing area (Reference 13). A drainage study done by Yost and Gardner Engineers for the City of Phoenix on the Tenth Street Wash, dated July 1975, was used to revise the profiles on that flooding source (Reference 4). Flood boundaries on Moon Valley Wash were revised by the city in November 1976 and appropriate changes made to the maps.

The as-yet unpublished Flood Insurance Study for the unincorporated areas of Maricopa County, Arizona, was coordinated with this study and boundaries were obtained for areas of the county recently annexed by the City of Phoenix (Reference 12).

This study is authoritative for purposes of the Flood Insurance Program, and the data presented here either supersede or are compatible with previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Insurance and Mitigation Division of the Federal Emergency Management Agency, Regional Director, Region IX Office, 211 Main Street, Room 220, San Francisco, California 94105.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Cave Creek							
Reach 1	50,75,95,115	-1.3	-0.4	+1.1	015	A3	Varies
Reach 2	50	-2.7	-0.6	+1.2	025	A5	Varies
Reach 3	50	-4.5	-1.0	+2.5	045	A9	Varies
Reach 4	50	-4.1	-1.1	+3.1	040	A8	Varies
Reach 5	50	-6.4	-1.9	+5.0	065	A13	Varies
Reach 6	50	-4.9	-1.2	+5.7	050	A10	Varies
Reach 7	50	-4.6	-1.1	+6.1	045	A9	Varies
Reach 8	30,50	-2.6	-0.0	+3.1	025	A5	Varies
Reach 9	30	-4.5	-0.9	+6.0	045	A9	Varies
Reach 10	30	-2.3	-0.8	+1.9	025	A5	Varies
Sheet Flow North of Beardsley Road, south of Deer Valley Road and west of Cave Creek	30	SHALLOW	FLOODING -	DEPTHS 1,2	FEET	AO	--

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOOD INSURANCE ZONE DATA

CAVE CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
East Fork Cave Creek							
Reach 1	50	-4.5	-1.3	+2.5	045	A9	Varies
Reach 2	50	-2.1	-0.5	+1.1	020	A4	Varies
Reach 3	30,35,50	-0.9	-0.3	+0.7	010	A2	Varies
Sheet Flow North of Thunderbird Road, west of Coral Gables Drive, south of Greenway Road and east of 11th St.	50	SHALLOW	FLOODING -	AVERAGE DEPTH	2 FEET	A0	--
Cave Creek Tributary at Deer Valley Road							
Reach 1	30	-0.8	*	+0.5	010	A2	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

*Data not available

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOOD INSURANCE ZONE DATA

EAST FORK CAVE CREEK AND CAVE CREEK TRIBUTARY AT DEER VALLEY DRIVE

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
West Branch East Fork Cave Creek							
Reach 1	50	-4.5	-1.3	+2.5	045	A9	Varies
Reach 2	50	-2.1	-0.5	+1.1	020	A4	Varies
Echo Canyon Wash							
Reach 1	80	-2.2	*	+2.1	020	A4	Varies
Reach 2	80	-4.4	*	+2.8	045	A9	Varies
Reach 3	80	-2.4	*	+2.2	025	A5	Varies
Moon Valley Wash							
Reach 1	50	-3.5	*	+4.0	035	A7	Varies
Scatter Wash							
Reach 1	25	-2.0	*	*	020	A4	Varies
Reach 2	25,30	-3.3	*	*	035	A7	Varies
Reach 3	30	-0.8	*	+0.3	010	A2	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

*Data not available

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ
(MARICOPA CO.)

FLOOD INSURANCE ZONE DATA

WEST BRANCH EAST FORK CAVE CREEK, ECHO CANYON WASH, MOON VALLEY WASH AND SCATTER WASH

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
East Branch Scatter Wash							
Reach 1	30	-2.1	*	*	020	A4	Varies
Myrtle Avenue Wash							
Reach 1	75	-1.0	*	+1.3	010	A2	Varies
Flynn Lane Wash							
Reach 1	75	-0.5	*	+0.5	005	A1	Varies
Reach 2	75	-1.2	*	+1.0	010	A2	Varies
Tenth Street Wash							
Reach 1	50,75	-2.2	*	+2.1	020	A4	Varies
Dreamy Draw Wash East							
Reach 1	75	-1.0	*	+0.8	010	A2	Varies
Reach 2	75	-2.1	*	+1.2	020	A4	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map *Data not available

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

CITY OF PHOENIX, AZ

(MARICOPA CO.)

FLOOD INSURANCE ZONE DATA

EAST BRANCH SCATTER WASH, MYRTLE AVENUE WASH, FLYNN LANE WASH, TENTH STREET WASH AND DREAMY DRAW WASH EAST